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FURTHER STUDIES ON PREDACEOUS INSECT ENEMIES OF

DENDROCTONUS BREVICOMIS

Klamath Falls, Ore.

Northfork, Calif.

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FURTHER STUDIES ON PREDACEOUS INSECT ENEMIES

OF DENDROCTONUS BREVICOMIS

Introduction:

This report is intended as a progress report on the work done on the predators since the writing of the preliminary report dated April, 1923. In that report, titled "Preliminary Studies on Predaceous Insect Enemies of Dendroctonus brevicomis", the field notes and literature on the subject were reviewed and an account and results of the feeding studies completed in March 1923, were given. The preliminary studies showed that the clerid, T. nigriventris and the ostomid, Temnochila virescens var. chlorodia were by far the most important of the predaceous enemies of D.b. since they were voracious feeders upon them in both the larval and adult stages and were closely associated with them under natural conditions thru all stages of development.

In continuing the studies it was decided to learn as much as possible about the life history and habits of these two important predators. Some notes were also taken, however, on Cucujus clavipes var. puniceus and Enoplium longum the importance of which was still under some question as well as on T. sphegeus. It is still too early to write a final report but it was thought best to record and summarize the observations made during the summer of 1923 and so bring our knowledge of the subject up to date.

Procedure:

The writer started field work on the So.Ore.-No.Calif. Project about April 25, 1923 and spent a little over a month in control camps on Area II. During this time a large number of trees were examined and notes taken on the stage of development in which the predators were found at that time. In all cases the D.b. stage was also given to aid in working out the relation between the life history of the predators and D.b.

On May 12, a temporary field station was established in the Antelope Unit of the Control Project near Klamath Falls, Ore. To study the development of the predators more closely three yellow pine trees were located shortly after being attacked by D.b. and the development of the D.b. brood and its predators was closely followed thru the season to September 15. Two cage experiments were also carried out during the season.

The observations made during the summer are given in detail, chronologically by species at the end of this paper. The following account

covers the most important points. The life histories of T. nigriventris and T.v.c. are shown graphically on Diagram I. and II.

Temnochila virescens var. chlorodia

It is hard to decide whether this predator or T. nigriventris is the most important enemy of D.b. It is certain that either of these two species are more important by far than any other predaceous insect.

Egg Stage

The eggs are usually laid under the bark scales along the sides of bark crevices where the adults are usually found. However, they are frequently found under the outermost bark scales in the same situations that T.n. eggs are laid. The eggs are about .07" -09" in length and .017" - .02" in diameter at the largest point, and tapering slightly toward each end. They are sub-cylindrical in shape and have no surface markings. They are an opaque white when first laid, becoming semi-transparent for the anterior 1/8 and the posterior tip, before hatching. As many as 30 have been found in one mass, closely fitted into a mat of one layer in thickness. The number of eggs laid by each female is not known but must be at least 30 and probably two or three times this number. The incubation period is around 14 days under average conditions.

Larval Stage:

The hatching of a larva was observed on August 9, the first indication was the movement of the new larva in the egg causing a bending motion of the whole egg. This continued intermittently until the anterior end of the shell broke open on the lower side. Thru this opening the larva gradually worked its body. When first hatched the larva was all a semi transparent white, except the tips of its mandibles which were a dark brown. It was slightly over 1/16" in length.

After hatching the larvae work their way thru to the inner bark taking advantage of cracks between the bark scales and the entrance and ventilation holes of the D.b. After reaching the inner bark they begin to feed on the young D.b. larvae, following them as they work back into the middle of the bark. They develop with the D.b. and feed upon the larvae, pupae and new adults while still in the larval stage. They burrow their way thru the bark at will going from one D.b. to the next while feeding.

Only the larvae which hatch by July 1, complete their development during one season at Klamath Falls. Of a large number of larvae followed thru from the latter part of June and first part of July to the middle of September,

only a few reached the adult stage while many of them at that time were still only partly grown larvae. These overwinter and pupate in the spring. The larval period varies from about three or four months for those that complete their development in the one season to ten or eleven months for those that overwinter as larvae.

Pupal Stage

The pupal stage is passed in an unlined cell in the middle or outer bark at the place where the larvae finished feeding, Plate I. Fig. I. There is evidently no larval migration such as is found among the clerids. The pupal stage of the individual lasts around two weeks.

Adult Stage

The adults emerge a few days after changing to the adult form. They are usually found in the crevices of the bark, tho they may be seen crawling about on the bark at times. They are not nearly as active as the clerids and catch their prey by stealth. Unfortunately they do not confine their feeding to the D.b. adults and will probably feed on any insect that they can capture. On August 8, a T.v.c. adult was observed while it killed and partly consumed a T.n. adult. The T.v.c. first seized the clerid with its mandibles at the juncture of the head and thorax; it then used its front legs and at times the middle pair to hold its victim against the bark while it fed upon the internals.

The average adult life of a T.v.c. is about four months for those that do not overwinter, and about ten to twelve for those that do. The adults overwinter in the bark crevices of infested trees. (See end of report for details).

Results of Cage Experiment with T.v.c.

Of 28 adults caged June 23, 15 were still alive on September 17. This shows an average life of over three months when caged.

During this period D.b. adults were fed to the T.v.c. and a check kept on the number eaten during two, two week periods. It was found that on the average a T.v.c. adult ate .935 D.b. adults per day.

It was found possible to secure oviposition by the T.v.c., and larvae to about half grown were reared in the infested bark sections which were put in the cage.

Life History

(See life history diagram).

The different generations tho badly mixed can be roughly grouped into one that attacks the D.b. overwintering generation and one that attacks

the D.b. summer generation. All stages overwinter except the egg stage. Since the T.v.c. will feed on secondary insects the relation between T.v.c. and D.b. is not as close as between T.n. and D.b.

Thanasimus nigriventris

This species is less prolific and a lighter feeder than T.v.c. but is usually a little more abundant and on D.b. trees feeds almost entirely on the different stages of D.b. They have been observed to feed on Ips spp. but not commonly. The adults are much more active than the T.v.c. adults and probably kill a greater number of D.b. adults tho their total consumption of insects is less than T.v.c.

Egg Stage

While ovipositing the females run nervously about on the bark of an infested tree stopping frequently to feel under an outer bark scale with the ovipositor. The eggs are usually laid singly or in groups of from two to five, although in one case, ten were found in one group. Caged clerids oviposited eggs on the outside of the bark with no attempt at concealment but under natural conditions they are always concealed. The ovipositor is forced under bark scale for about an eight of an inch and to find the eggs it is necessary to flip off the outer scales.

The actual number of eggs laid per female was not determined but it is probably much smaller than the number laid by T.v.c. It is believed that about 15-20 per female would be a fair estimate. The eggs are described in the report on preliminary studies. The individual incubation period is about 10-14 days under average conditions. (See Plate I. Fig 2 and 3.)

Larval Stage

The hatching of a clerid egg is about the same as that of a T.v.c. (See notes at end of report) The clerid larvae also work their way thru to the inner bark and work out with the D.b. larvae.

T.n.?

Very few, if any of the D.b. complete their development during one season. All of the broods followed thru the season reached the prepupal stage during the fall and overwintered as such. This indicates a larval period, for the individual, of about 10-12 months.

Many of the larvae, especially in certain trees, migrate to the base of the tree upon which they have been feeding and form their prepupal cell in the outer bark at the base of the tree. It is not known what proportion of the larvae do this nor why it is that on some trees practically all of the larvae migrate to the base of the tree while on other trees apparently all of the larvae pupate where they finish feeding. 60 T.n. pupal cells were found from a partial examination of the base of one D.b. abandoned tree. The pupal cells are lined with a white silky substance. (Plate II, Figs. 1. and 2.)

Pupal Stage

This stage is passed in the above described pupal cell in the outer bark of the tree upon which the larvae have been feeding, either at the base of the tree or anyplace on the trunk where the larvae have been feeding. (Plate III. Fig. 1 and 2.) The pupal period of the individual is about seven to fourteen days.

Adult Stage

The adults emerge within a few days after pupating and fly to freshly attacked D.b. trees where they are usually found running up and down the trunk during the warm part of the day. The life of caged adults was about 40 days so the life of an adult under natural conditions would probably be at least two months.

Life History in Relation to D.b. Life History - (See diagrams)

Although there is a lapping over of T.n. generations that makes them difficult to separate they can be divided for practical purposes into the generation that feeds on the D.b. overwintering generation and the one that feeds on the D.b. summer generation. By comparing the T.n. life history diagram with one of D.b. the relation between the two will be brought out.

The winter generation larvae of 1922 were found in the prepupal larval stage late in the fall of 1923 so it is probable that some of the larvae live over the second winter giving them a larval period of at least eighteen months.

No adults have been found or recorded during the winter months and it is doubtful if any of them over-winter.

Aulonium longum

This species has been found feeding on living D.b. larvae and pupae in a few cases and it was thought that it might be of some importance since it is usually very common on D.b. infested trees. Unsuccessful attempts to get either the larvae or adults to feed on any of the stages of D.b. led the writer to doubt its importance. (See preliminary studies) This stand is supported by the work of Dr. Craighead who reared the A.l. larvae to the adult stage without living insect food of any kind.

Although they are evidently not normally predaceous a few notes on their habits and life history would not be inappropriate here.

The parent adults are found under the bark in the D.b. galleries soon after the D.b. adults start laying eggs. The A.l. eggs are probably laid under the bark. The larvae upon hatching work out into the bark following the D.b. larvae. Their development parallels the development of the D.b. with a slight lag. They pupate in the inner layer of the outer bark and emerge as adults shortly after the emergence of the D.b. adults.

Cucujus clavipes var. puniceus

During the feeding experiments (preliminary studies) it was found that the adults of this species would feed readily upon D.b. adults but it was doubted if it was naturally of importance as a D.b. predator since it was not found associated with D.b. in the field.

The field study confirmed these doubts as C.c.p. was commonly found only in trees which had been abandoned by D.b. for from a few days to a year or more. Two adults were found "in copulo" under the bark of a D.b. abandoned tree April 26, '23. On the same date an adult was found under the bark of a partly abandoned D.b. tree, feeding on an Aulonium longum adult.

Further Studies

These studies will be continued and the preceeding observations will be checked and the life histories will be worked out in greater detail by more field observations. The principle work to be done, however, is to determine the actual importance of T.n. and T.v.c. under natural conditions. It is proposed to cage living trees and introduce a definite number of D.b. T.v.c. and T.n. in some cages and D.b. only in others. By comparing the number of D.b. attacking, developing and emerging in the two sets of cages it will be possible to determine the effect of the predators on the adult and brood mortality of D.b. under approximately normal conditions.

Fig. 1. Pupal cells of Hemerobius virescens var. Chlorodia in yellow pine bark. Slightly over natural size.

By - Patterson.

Fig. 2. N. dispersaria eggs on yellow pine bark. Enlarged about 3 X.

By - Miller and Person

Fig. 3. Abandoned T.M. eggs as found on a yellow pine bark scale. Enlarged 3 X.

By - Patterson.

PLATE II.

Fig. 1. Ecoclerus sphaerus larva in pupal cell in yellow pine bark from base of tree. Very similar to T. nigriventris. Slightly enlarged. By - Patterson.

Fig. 2. Pupal cells of T. nigriventris in yellow pine bark from base of tree. Slightly enlarged. By - Patterson.

PLATE III.

Fig. 1. Base of D.b. abandoned yellow pine showing position of pre-pupal T. nigriventris larva. about 2/5 natural size.

By - J. E. Patterson

Fig. 2. "Close-up" of T.nigriventris larva shown in Fig. 1. Approximately natural size.

By - J. E. Patterson.

Field Notes - Temnochila virescens var. chlorodia

Misc. Observations - Klamath Falls, Ore.,(Area II.)

4-24-23 - Medium sized larvae in bark of D.b. abandoned tree
Larva in D.m. cell on D.b., D.m. tree.
Newly hatched larva in bark crevice in green tops of tree infested lower down with D.b. large larvae.

4-30-23 - Medium sized larvae, in bark of D.b., D.m., summer 1922 tree.

5- 9-23 - Adults common in bark crevices of tree infested with D.b. and D.m. small larvae.
6 very small to medium sized larvae, in and under bark of tree infested with D.b. large larvae to new adults
Small to full grown larvae in bark containing D.b. large larvae to new adults.

5-14-23 - Prepupal larvae, abundant in cells in bark of D.b. 1922 summer brood tree.
Large larvae, abundant, in bark of D.b. 1922 summer brood tree.

5-24-23 - Adult in bark crevice and one large larva under the bark of tree infested with D.b. pupae.

5-29-23 - Small larvae, in the bark with D.b. pupae of new adults and one adult in bark crevice of same tree.

6- 6-23 - Pupa and larvae in bark of partly abandoned D.b. tree.

6- 8-23 - Adult, feeding on D.m. pupa beneath the bark.
Larvae, small to large, found in and under the bark of D.b. D.m. 1922 winter trees.

6-20-23 - Pupa, in unlined cell, in back of D.b., recently abandoned tree
Large larva, in the same tree.

6-22-23 - Adults, common, in bark crevices of windfall recently attacked by D.b.

7-21-23 - 1 new adult, 4 pupae and 6 prepupal larvae in pupal cells in D.b. 1922 winter brood tree.

8-23-23 - Adult observed as it killed and partly consumed a T.n. adult on 1 yellow pine tree.

9-10-23 - Large larvae common in the bark of a partly abandoned tree. Larvae, 1/2 to full grown, in bark at the base of a D.b. 1922 winter brood tree.

9-14-23 - Prepupal larvae, in unlined cells in abandoned bark of D.b. 1923 summer brood tree.

Northfork, Calif. (Cascade)

11-6-23 - Larvae 1/2 to full grown in bark on main trunk and at the base of a D.b. 1922 winter tree.

Observations from Sample Tree #1 - Klamath Falls, Ore.
(Area II. - Antelope Unit)

6-13-23 - D.b. parent adults and eggs
No predators noted.

7-18-23 - D.b. medium sized larvae.
T.v.c. - 2 very small larvae found under the bark in D.b. galleries.

7-27-23 - D.b. mostly pupae.
T.v.c. - medium small larvae.

8 -7-23 - T.v.c. half grown larvae.

8-14-23 - D.b., pupae to emergence.
T.v.c. - larvae half to 3/4 grown.

Sample Tree #2.

6-13-23 - D.b. just attacking. No predators found.

6-30-23 - D.b., parent adults, eggs and young larvae.
T.v.c - adults and eggs found.
Twenty were found closely fitted together in one group under an outer bark scale.

7-19-23 - One adult found in a bark crevice and small larvae found under and in the bark.

7-26-23 - D.b., large larvae & pupae.
T.v.c. - adults running about on the bark
Half grown larvae found in D.b. larval tunnels and pupal cells.
~~T.v.c.~~

8-15-23 - D.b., pupae to emerged.
T.v.c. 3/4 grown larvae found in the bark.

8-27-23 - D.b. emerged
T.v.c. - 5 large larvae found in the abandoned bark.

9-14-23 - T.v.c. - 2 new adults and 10 prepupal larvae were found in cells in the D.b. abandoned bark.

Sample Tree #3.

7-13-23 - A group of 14 newly hatched T.v.c. larvae found under an outer bark scale with their abandoned egg shells. When exposed they immediately began to crawl about and in 2 minutes they had all disappeared into the cracks between the bark scales or into D.b. tunnels. Other observations similar to Sample Tree #2.

Cage Experiment

6-23-23 - A large number of T.v.c. adults were found in crevices in the bark of a large yellow pine windfall which had been recently attacked by D.b. and Ips oregoni.

28 adults were put in a cage with slabs of wood from the windfall with the bark on. The slabs contained some new D.b. adults and eggs. The cage used was made from a 5 gallon kerosene can by cutting a 6" x 6" hole on each side and soldering a piece of copper straining cloth on one side and fitting a sliding glass door on the other. D.b. adults were put in for food. A careful count of the number put in and the number eaten was kept, for two periods of two weeks each. During the first period each T.v.c. adult ate .91 D.b. adults per day and during the second period .96 D.b. adults per day.

7-3-23 - A group of 6 T.v.c. eggs were found under bark scales along the side of a bark crevice.

7-23-23 - 14 T.v.c. eggs and 2 new larvae found in one of the t slabs.

8- 6-23 - 17 eggs and 13 new to small larvae were found in one slab. 4½ x 8" in area. Some of the eggs were saved for rearing.

8- 9-23 - 3 of the eggs found 8 -6-23 hatched.

8-20-23 - Another slab of bark was examined and 3 T.v.c. larvae small to 1/2 grown were found. No eggs were found.

9-17-23 - Only 15 T.v.c. adults were still alive and the experiment was closed.
Since the 28 adults were caged 6-23-23 the average adult life of these predators, when caged, must be at least three months. Under natural conditions it is probably considerably longer.
One larva was reared in a glass vial from a newly hatched larva to a large larva. It was fed with D.b. larvae.

Thanasimus nigriventris

Misc. Notes - (Area II.) Klamath Falls, Ore. - Yellow Pine

4-25-23 - Large larvae very common in bark of tree infested with D.b. large larvae.

5- 9-23 - Full grown larva in bark of tree infested with D.b. large larvae to new adults.

5-14-23 - 1 new adult in pupal cell in bark of D.b. summer 1922 tree.

5-17-23 - Large larva, in bark of D.b., partly abandoned tree.

5-18-23 - 1 adult, running about on a stump.

5-24-23 - 1 pupa, in cell, in bark of tree containing D.b. pupae.

5-29-23 - 3 full grown larvae, in bark of tree containing D.b. pupae and new adults.
2 pupae, in outer bark near base of tree containing D.b. pupae and new adults. (1 saved for rearing, changed to adult form 6-29-23)

6-8 -23 - Large larvae in the bark of tree containing D.b. pupae and new adults

6-20-23 - 2 adults, running about on green windfall containing a few Ips broods.

6-27-23 - adults running about on windfall infested with D.b. and I. spp

9-10-23 - Full grown larvae, common in bark of tree infested with D.b. large larvae and pupae.
A number of deserted pupal cells found in the outer bark at the base of a D.b. 1922 winter brood tree.

9-13-23 - A number of abandoned pupal cells found in the loose outer bark at the base of a D.b. 1922 winter brood.

9-14-23 - A group of 4 trees infested with D.b. small larvae was examined - no T.n. adults and only a very few eggs were found.

9-17-23 - 2 prepupal larvae, in pupal cells in loose outer bark at base of D.b. 1922 winter brood tree.

Jenny Creek, Ore.

10-10-23 - 60 T.n. pupal cells found in outer bark at the base of a D.b. 1922 winter brood tree. All of the cells were abandoned except 4 which contained prepupal larvae and 1 which contained a new adult.
A number of pupal cells found in the outer bark at the base of a 1922 winter brood tree. All were abandoned except 1 which contained a prepupal larva.

10-11-23 - Prepupal larvae abundant in bark at base of D.b. 1923 summer brood tree.

Northfork, Calif. (Cascadel)

11- 6-23 - A large number of abandoned pupal cells at base of D.b. 1922 winter brood tree.
Deserted pupal cells found in bark at the base and on the main trunk of D.b. 1922 winter brood tree.

11- 6-23 - Prepupal larvae very abundant both on the main part of the trunk and at the base in the outer bark in D.b. 1923 summer brood tree.

Observations from Sample Tree #1

A large tree the north side of which had been killed by D.b. in 1922:

6-13-23 - South side freshly attacked by D.b. contained D.b. parent adults, and a few eggs. No predators noted.

6-28-23 - T.n. adults very abundant, running up and down the tree, mating and laying eggs.
The oviposition of 3 eggs by one female was observed as follows: She moved about rapidly feeling into crevices and under outer bark scales, with her ovipositor which she used as a feeler, until finally a suitable place being found, she forced her ovipositor far under one of the outer bark scales, remained still for a few seconds, then moved her abdomen up and down several times, was still again and then withdrew her ovipositor and started in search of another place to oviposite. Three eggs were laid in one place and 2 eggs in another about an inch away. Eggs were usually oviposited under the outermost bark scales in groups of from 2-4, although in one instance 10 eggs were found in one group. Other eggs were found on the same tree.

7-27-23 - D.b. stage - large larvae, pupae and some new adults
T.n. - a few adults running about on bark but no eggs or new larvae. Two medium small larvae found in the D. b. infested bark.

8- 7-23 - One half grown larva found in the bark.

8-14-23 - D.b. stage - pupae, new adults and some emergence.
T.n. - 1 nearly full grown larva in the bark.

8-27-23 - D.b. mostly emerged with few pupae and adults.
T.n. - 1 large larva found in the D.b. abandoned bark.
2 prepupal larvae in silk-lined pupal cells in outer bark at the base of the tree.

Sample Tree #2 - A 30" tree with a good D.b. attack all around.

6-13-23 - D.b. just attacking. No predators found.

6-30-23 - D.b. eggs and young larvae found.
T.n. parent adults and eggs abundant
20 eggs found in an area of 2 sq. ft.
The hatching of one egg was observed. The egg split

open dorsally to the head and the larva worked itself out by twisting and bending. When free of the shell it crawled about on the bark until it found a crack between two bark scales, which it crawled into.

7- 2-23 - A T.n. adult was observed while feeding on an Ips emarginatus adult.

7-19-23 - T.n. adults abundant, running about on the trunk.

7-26-23 - D.b. larvae to new adults.
T.n. - adults still running about on the trunk.
One half-grown larva found in D.b. larval tunnel.

8- 3-23 - D.b. large larvae to emergence.
T.n. - 6 small to nearly full grown larvae found in 1/2 of a sq. ft. of bark. The tunnel of the T.n. larvae could often be followed from one D.b. tunnel to another and some of the T.n. larvae were found in D.b. pupal cells with the remains of their last victim.

8-15-23 - D.b.- pupae to emergence
T.n. ½ to full grown larvae found in the bark

8-27-23 - D.b. emerged.
T.n. - none were found in the D.b. abandoned bark but 6 prepupal larvae were found in silk lined cells in the loose outer bark at the base of the tree, from the surface of the mineral soil to the surface of the ground litter.

9-14-23 - T.n. - 6 more prepupal larvae found at the base of the tree. No larvae were found in the bark on the upper part of the tree tho three sq. ft. of bark was shaved up and examined.

Sample Tree #3 -(Observations very similar to those on tree #2.)

Observations made on two windfalls showed that both the D.b. brood and the clerids developed more slowly and with a much higher mortality than in standing trees.

Rearing in Vials

It was found possible to rear the T.n. larvae in small glass vials kept supplied with D.b. larvae and yellow pine inner bark. Considerable difficulty was experienced keeping the humidity favorable.

A T.n. egg found 6-30-23, hatched 7-5-23
The larva was feed all during the summer and is now overwintering as a prepupal larva (3-31-24)